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1973-1974 LIDAR OBSERVATIONS OF CIRRUS CLOUDS AT KWAJALEIN

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EXTENDED ABSTRACT

A series of surface-based lidar measurements was made in support of reentry tests at Kwajalein (9° 6'N, 167° 43'E). The measurement periods were conducted during May-June 1973, August 1973, December 1973 and March-April 1974. The lidar used was the SRI Mark IX, a ruby lidar (694.3 nm wavelength) installed within a van complete with its own power supplies, azimuth and elevation scanning capabilities and real-time digital data recording, processing and display system (Uthe and Allan, 1975). The digital data system was used to estimate cirrus cloud equivalent ice-water content as the cloud was being observed. Other supporting equipment included an instrumented WB-57 aircraft used for sampling cirrus cloud ice crystals (Jahnsen et al., 1974).

Figure 1 presents an altitude-time intensity modulated video display of cirrus cloud structure observed on 17 December 1973. The cloud is seen to consist of multiple thin layers that show horizontal density variations as the cloud traversed the lidar site. The cloud was subvisible to surface observers and was visible to the WB-57 pilot only when the aircraft operated above the cloud and the pilot observed downward in the direction of the sun. The equivalent ice-water content of the cloud was estimated from the lidar backscatter signature by deriving absolute backscatter coefficients based on normalizing clear-air lidar returns to standard tropical atmospheric density data and using the following expressions:

σ = volume extinction coefficient $= \dfrac{4\pi\beta}{0.25}$

N = crystal number density $= \dfrac{\sigma}{2\pi a^2}$

W = ice-water content $= 4/3\,\pi\, a^2 \rho N$

where β = volume backscatter coefficient

a = particle radius

ρ = ice density

N = particle number density.

The particle size (a) assumed was based on previously collected aircraft data that indicated particle size decreases with altitude. For the data shown in Figure 1 the maximum ice-water content derived from the lidar records was 10^{-4}g/m^3 and agreed with the aircraft cloud density measurements. During the course of the measurement program, lidar-observed clouds were inferred to have a maximum ice-water content ranging from 10^{-5} to 2 g/m^3. Although a wide range of cloud densities was observed, the aircraft and lidar-derived values normally agreed to within a factor of ± 2 when particle size was taken from the aircraft measurements. When particle size was based on previously collected data, uncertainties of the lidar derived ice-water content were increased by an additional factor of ± 2. Other results are given by Uthe and Russell (1977). This paper will present several data examples illustrating the high-altitude low-density and persistent nature of cirrus clouds over the Kwajalein area. The clouds were found to be more reflective of lidar energy than for

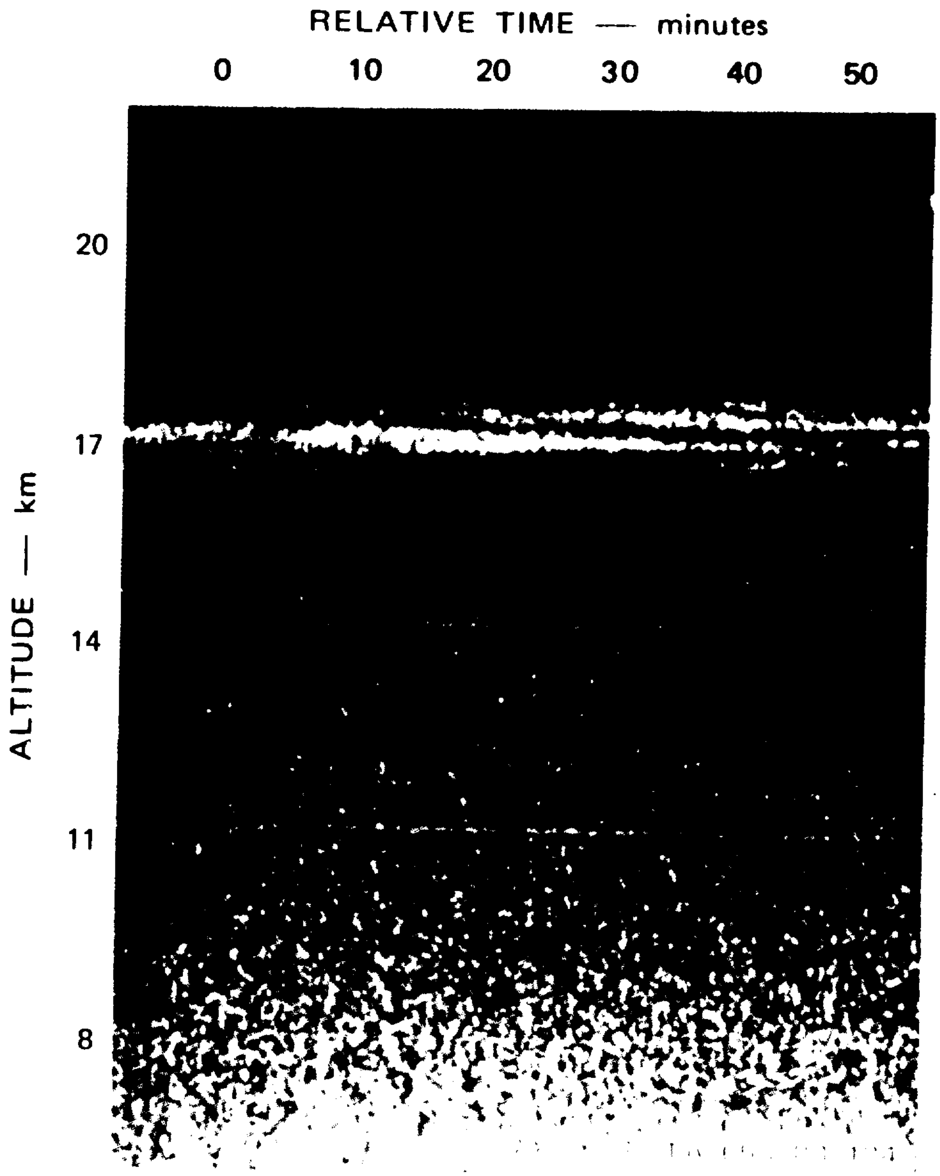

FIGURE 1 EXAMPLE OF HIGH-ALTITUDE LOW-DENSITY CIRRUS CLOUD OBSERVED OVER KWAJALEIN WITH THE MARK IX RUBY LIDAR SYSTEM (17 DECEMBER 1973, 1220-1330 LOCAL TIME). The maximum cloud density was computed as 2×10^{-4} g/m^3.

equivalent spherical particle clouds although backscattering from cylinders is expected to be significantly less than from equivalent volume spheres (Liou, 1972). Therefore, reflection of incoming solar energy and outgoing infrared energy emitted from the earth's surface and lower atmospheric constituents could serve as important climatic change mechanisms.

REFERENCES

Jahnsen, L.J., A.J. Heymsfield, and R.E. Carbone, 1974: PVM-5 Mission and WB-57F Instrumentation and Cloud Particle Measurements. Final Report, Contract DNA-001-73-C-0233. Meteorology Research, Inc., Altadena, California 91001 (MRI 74 R-1230).

Liou, K.N., 1972: Light Scattering by Ice Clouds in the Visible and Infrared: a Theoretical Study. J. Atmos. Sci, 29, pp 524-536.

Uthe, E.E., and R.J. Allen, 1975: A Digital Real-Time Lidar Data Recording, Processing and Display System. J. Optical and Quantum Electronics, 7, pp. 121-129.

Uthe, E.E. and P.B. Russell, 1977: Lidar Observations of Tropical High-Altitude Clouds. Radiation in the Atmosphere, H.J. Bolle, editor, Science Press, Princeton, pp. 242-244.